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Tomlinson et al.

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(54) **HEAT EXCHANGER WITH ENHANCEMENTS**

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(51) **Int. Cl.**^{7} **F28F 13/12**; F28F 3/14; F24H 3/00

(52) **U.S. Cl.** .... **165/170**; 165/109.1; 126/110 R

(58) **Field of Search** .... 165/109.1, 170, 165/171, 173, 175, 177, 147; 126/110 R, 126 R; 138/39

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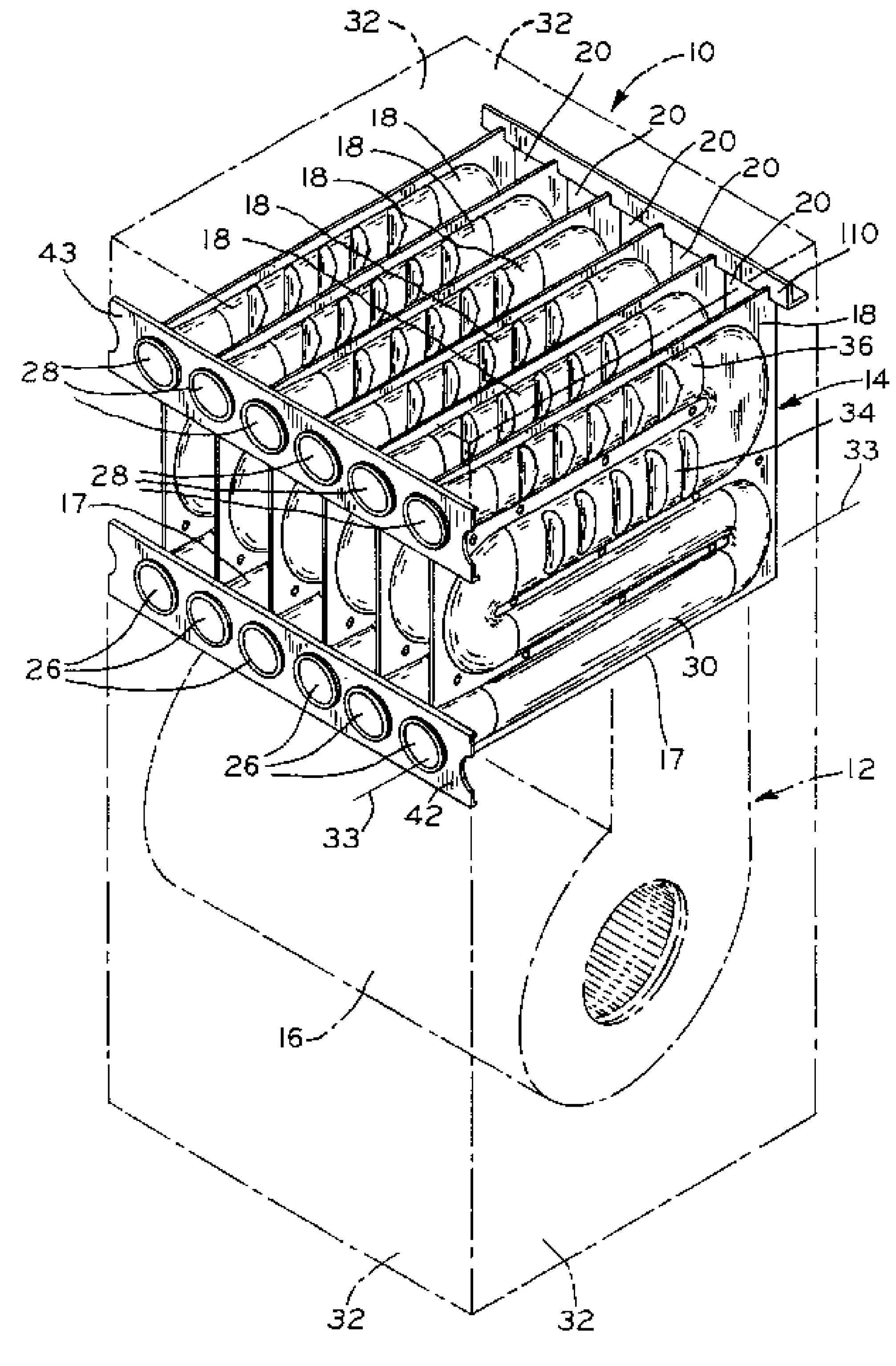
(57) **ABSTRACT**

A heat exchanger for use with a furnace, each heat exchanger includes a plurality of heat exchanger elements. Each heat exchanger element includes a pair of clamshells sealingly attached to one another. The heat exchanger element includes a longitudinal axis. A pair of depressions are disposed in each respective said pair of clamshells. The depressions face one another to form a passageway wall and a serpentine fluid passageway therebetween. At least a portion of the serpentine fluid passageway extends along the longitudinal axis. A plurality of enhancements are formed in the depressions and are disposed within the portion of the serpentine fluid passageway. The plurality of enhancements project into the serpentine fluid passageway. Each enhancement constitutes a corrugation having a substantially trapezoidal longitudinal cross-section. A longitudinally positioned passageway wall portion is extended between each adjacently positioned enhancements within each clamshell.

12 Claims, 7 Drawing Sheets



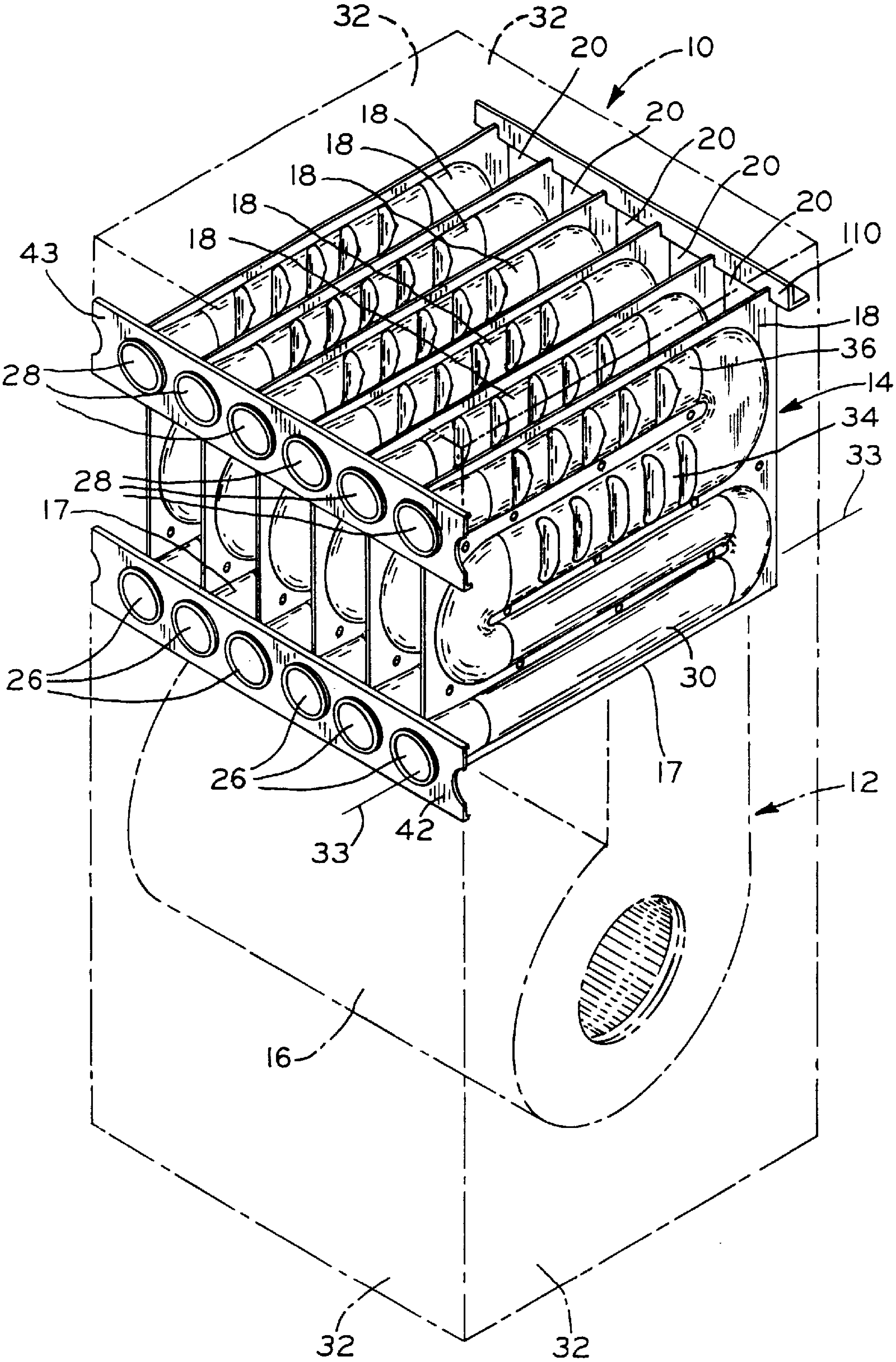

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FIG_1

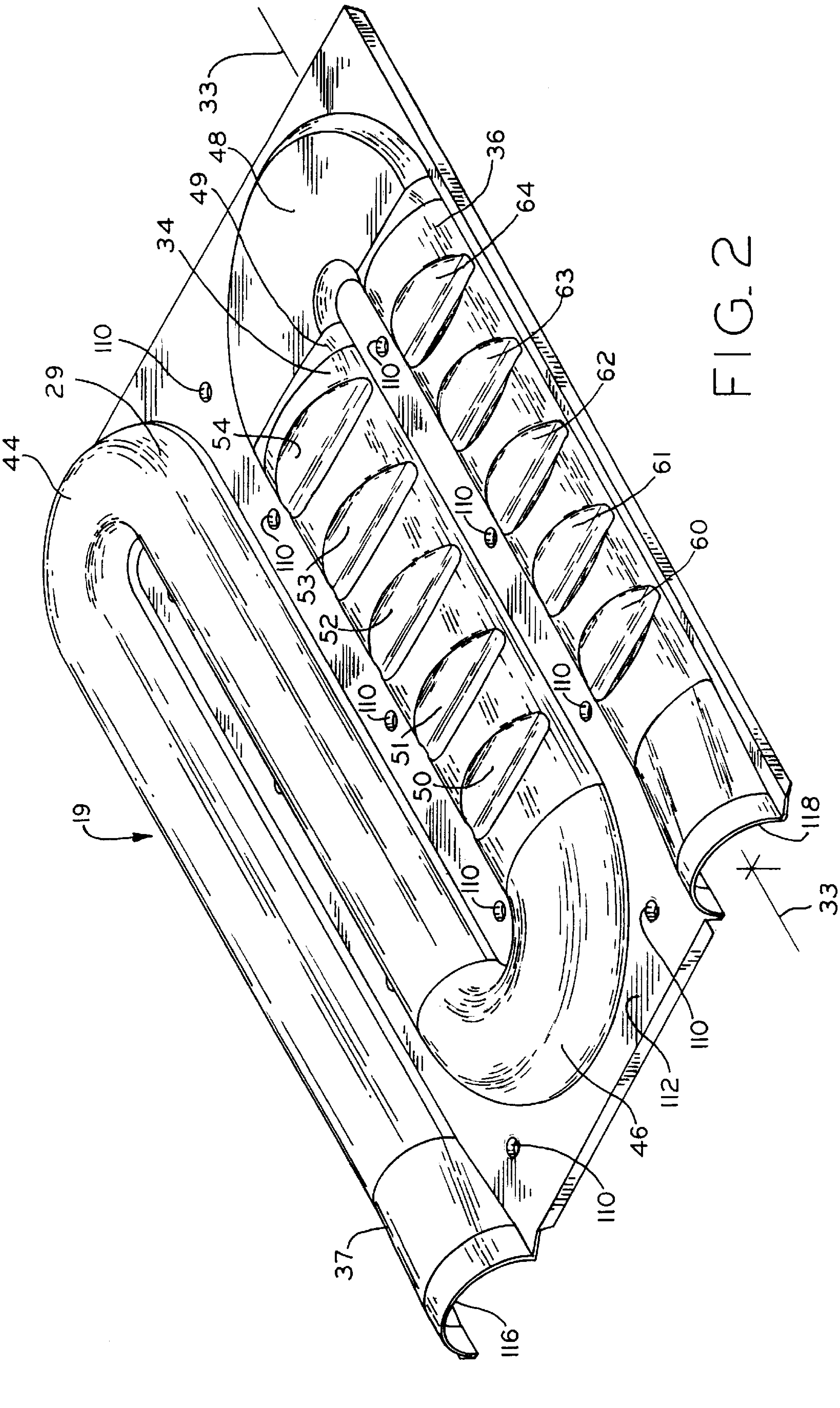
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FIG. 2

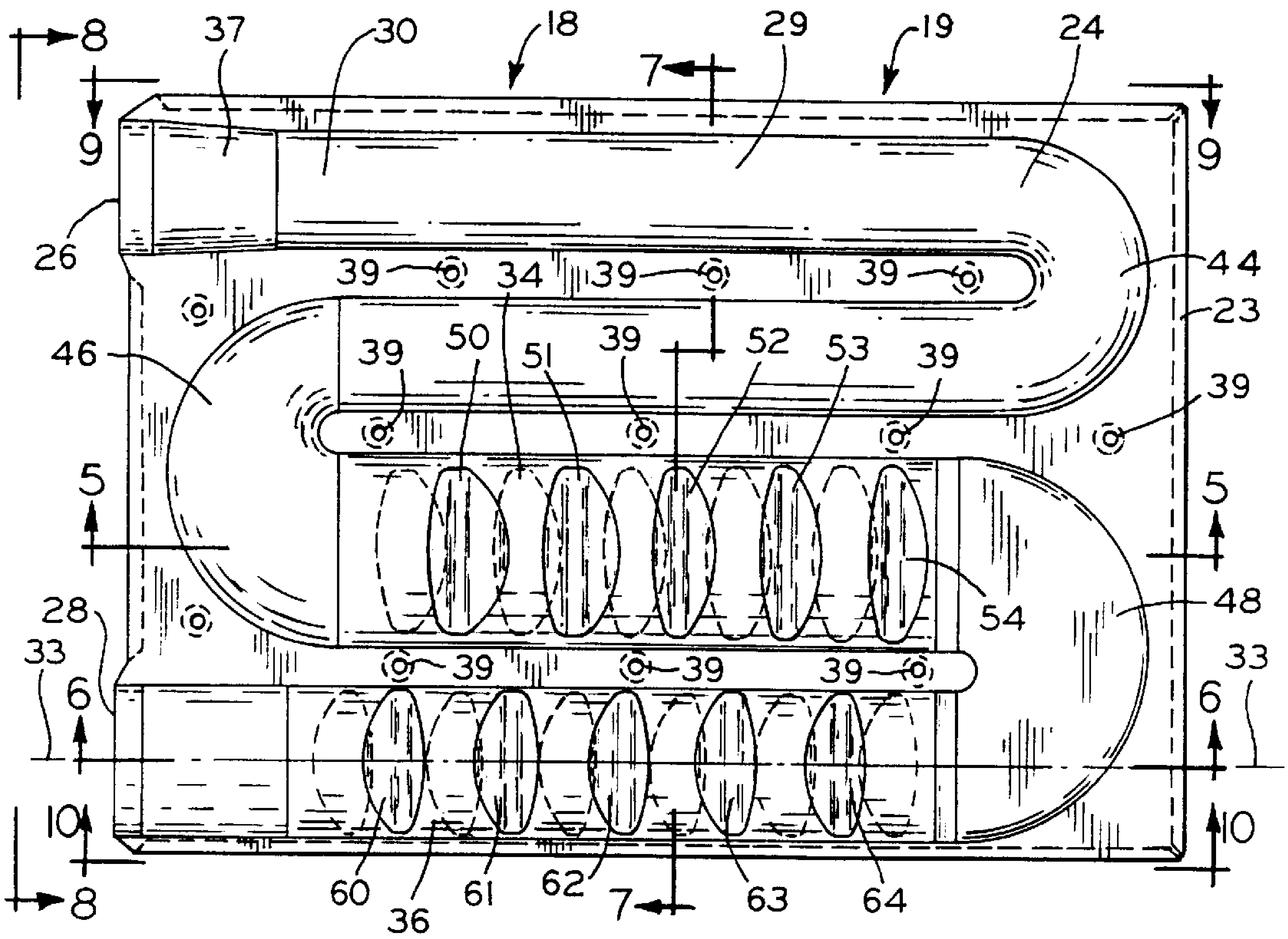
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FIG. 3

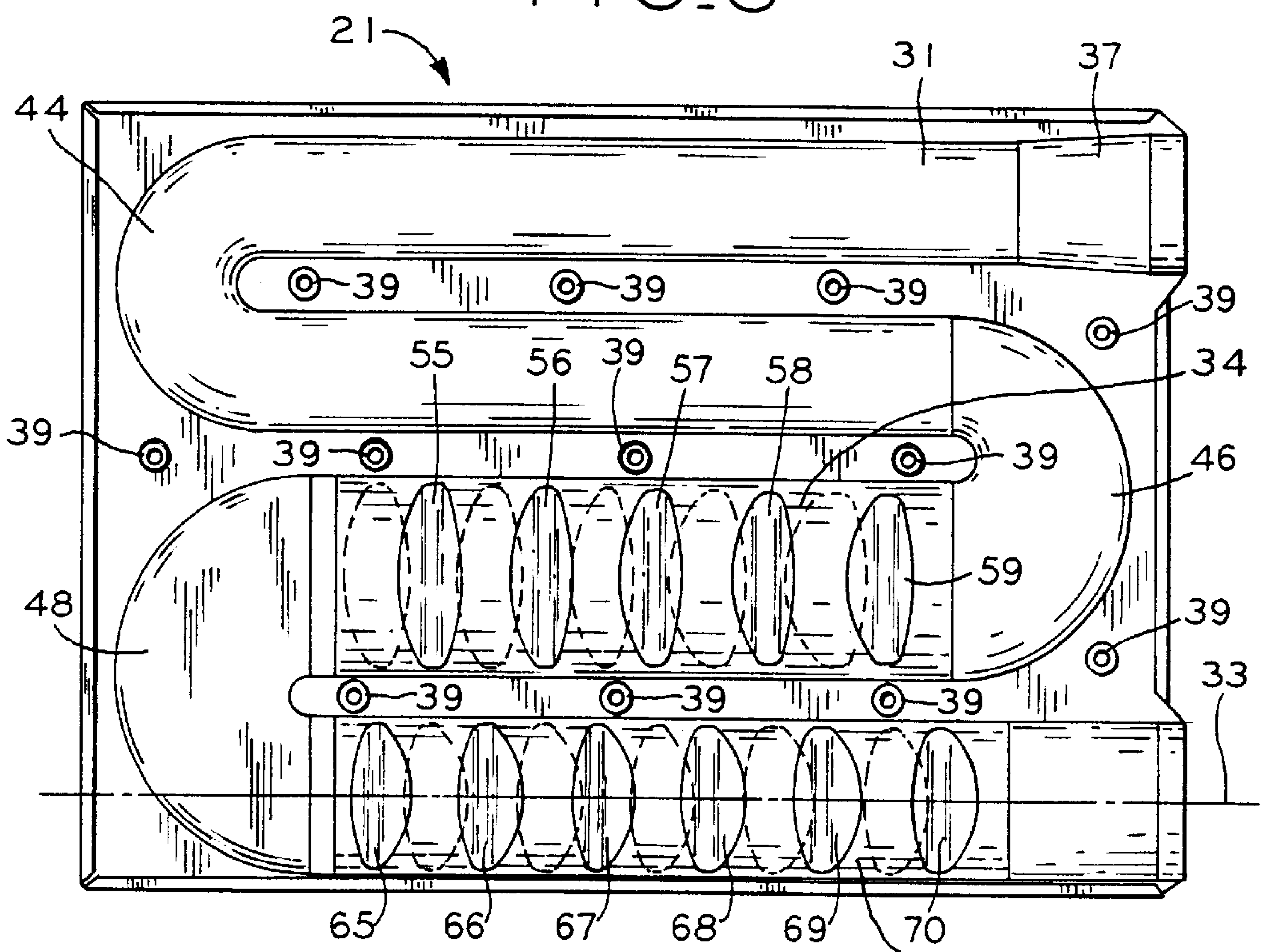
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FIG. 4

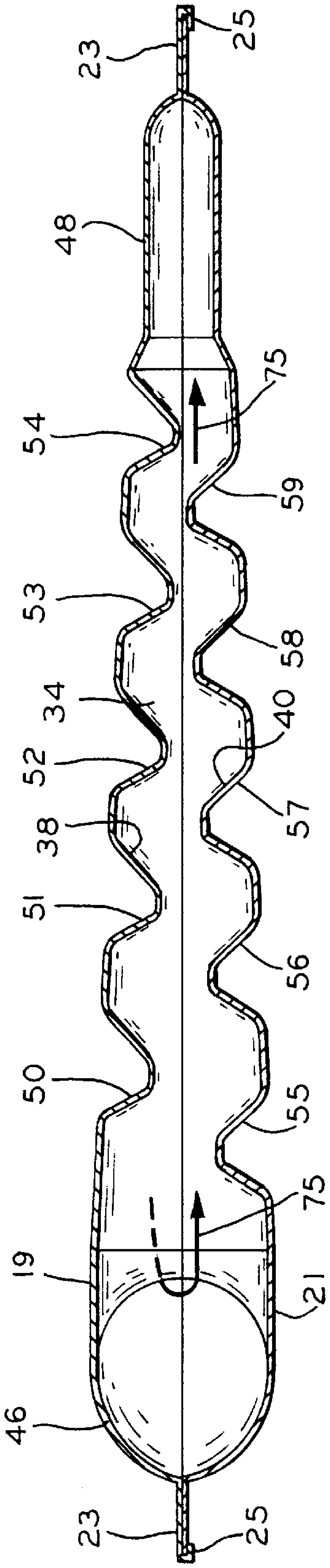
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FIG_5

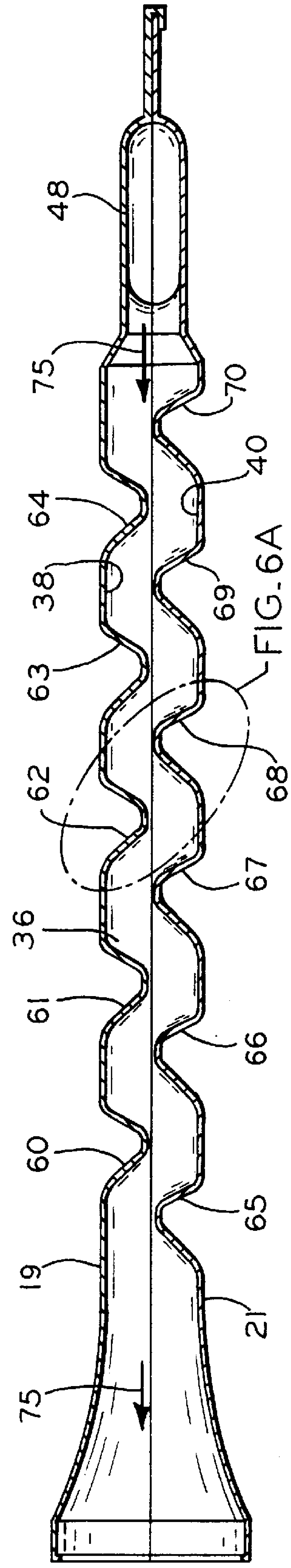
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FIG.6A
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FIG_6

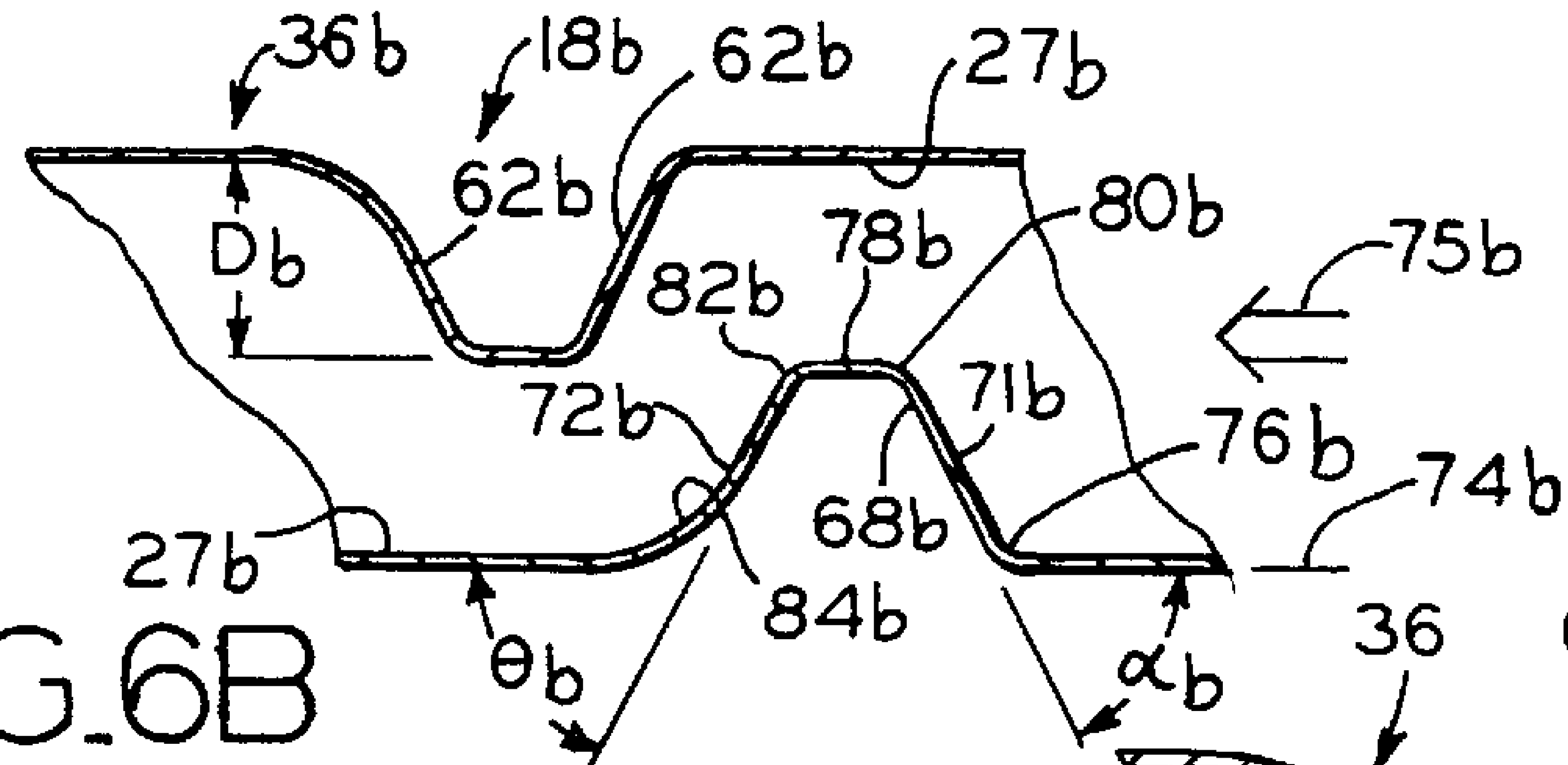

FIG_6B

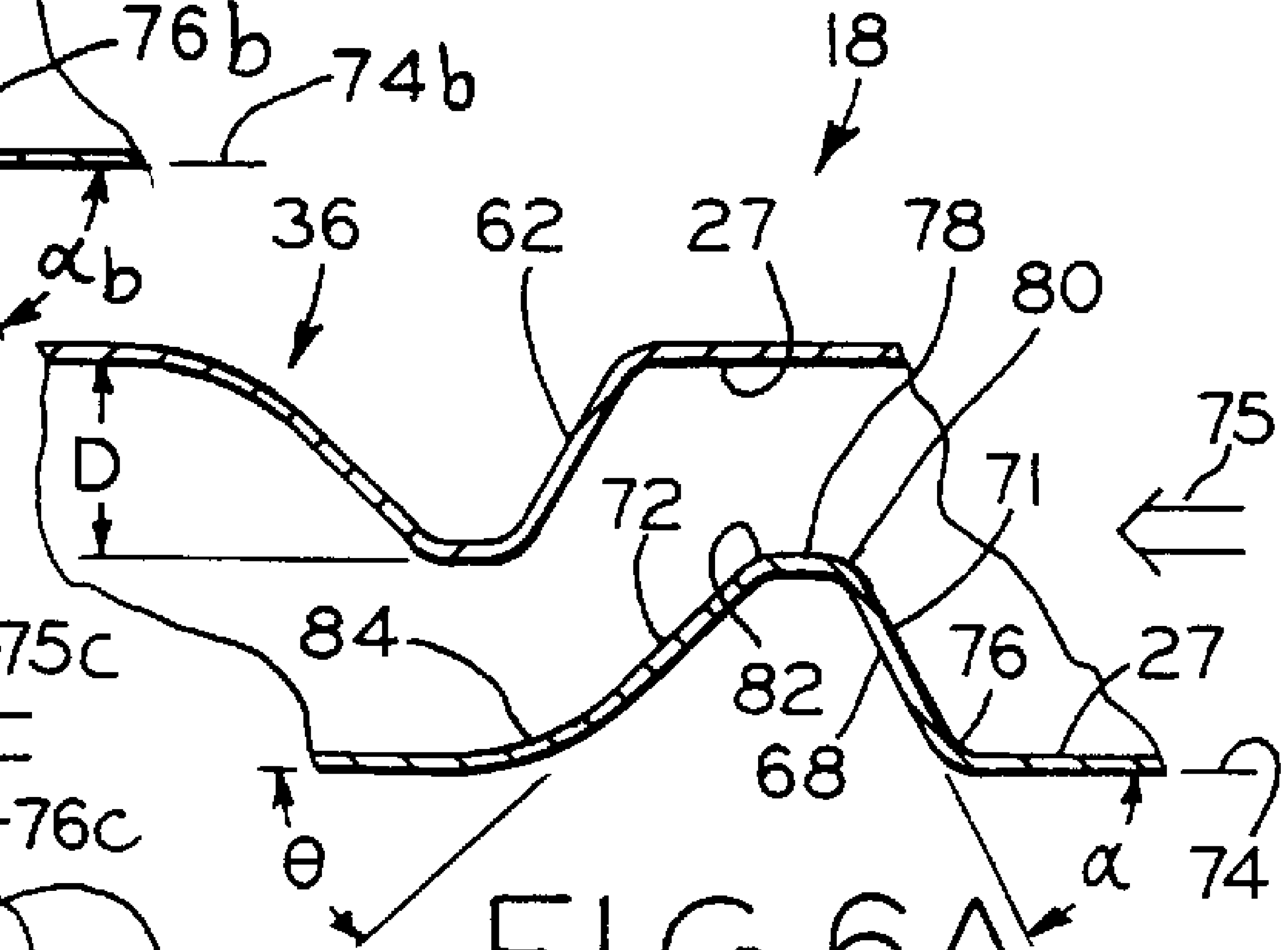

FIG_6A

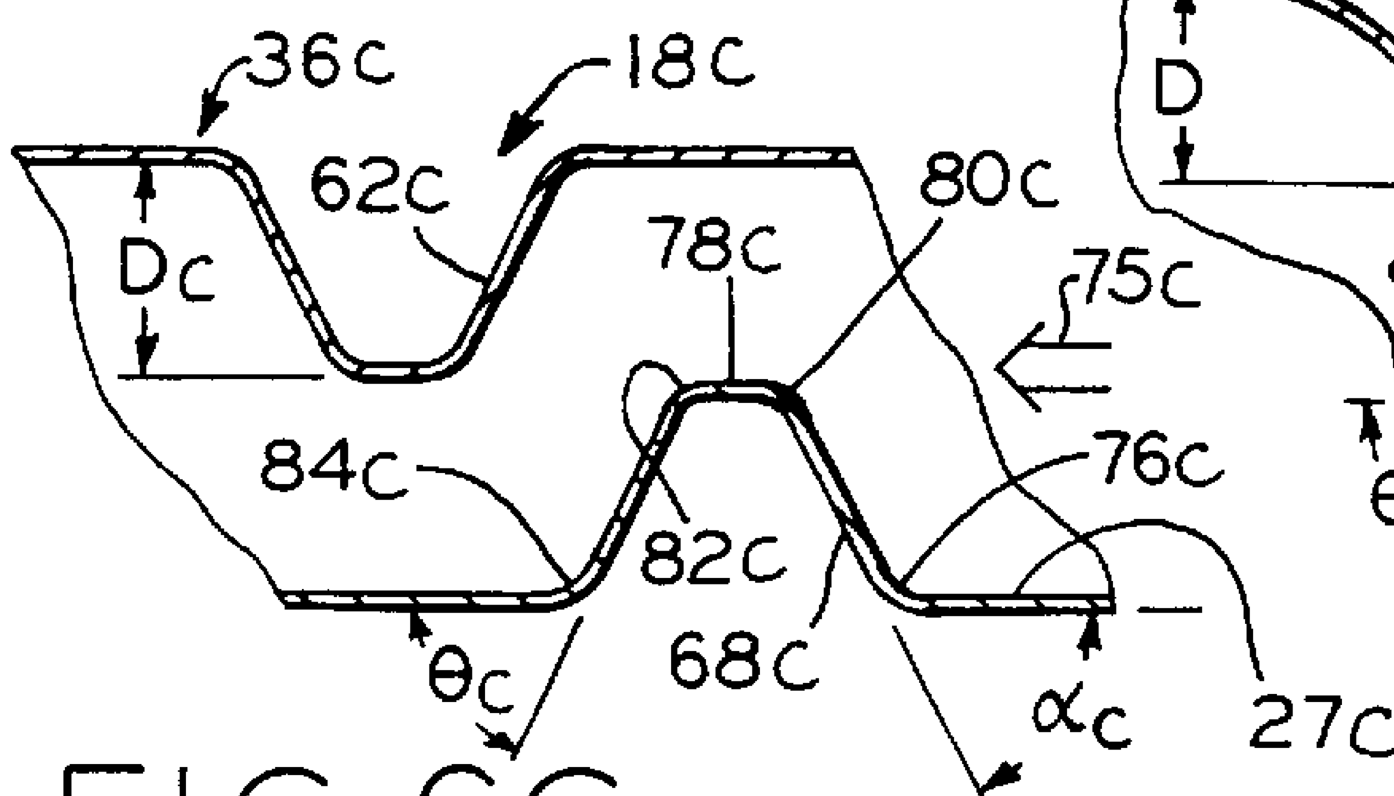

FIG_6C

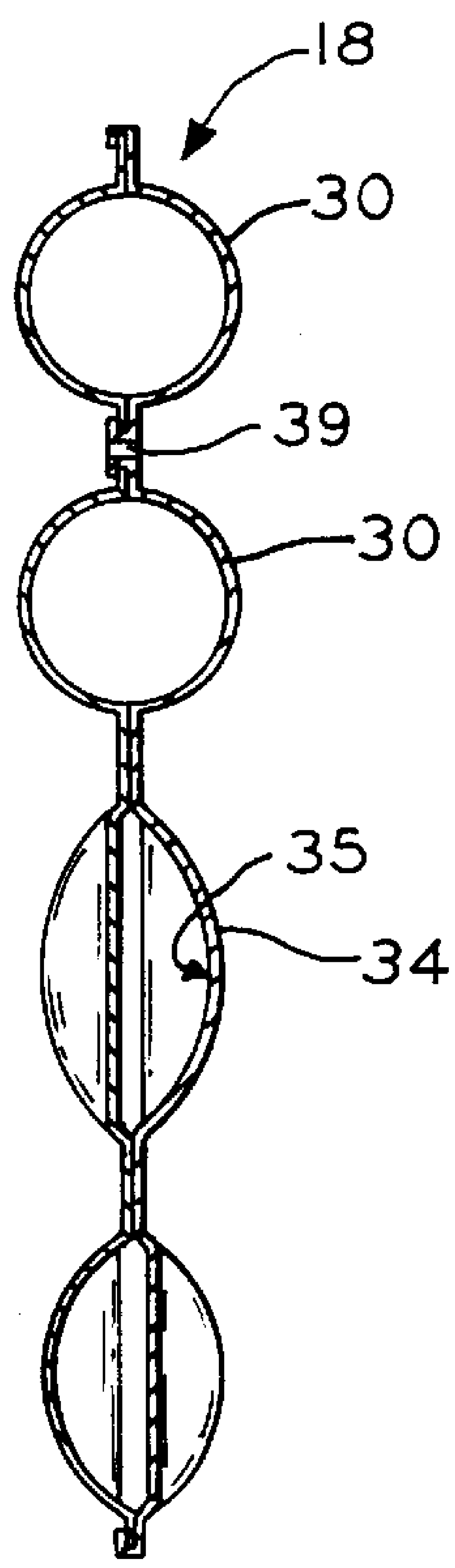

FIG_7

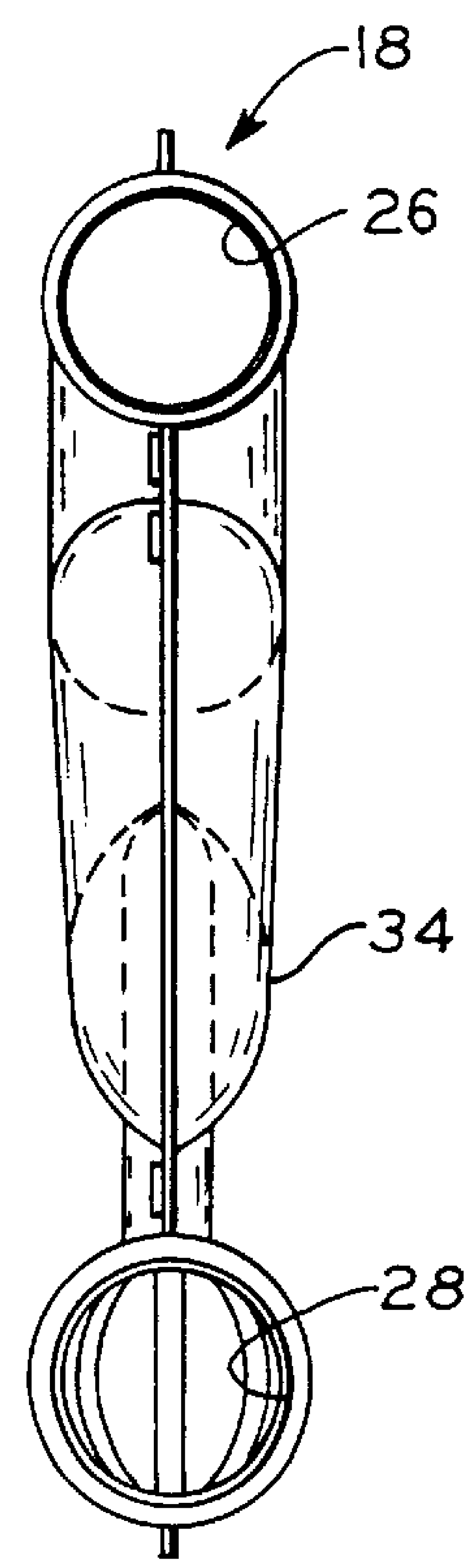

FIG_8

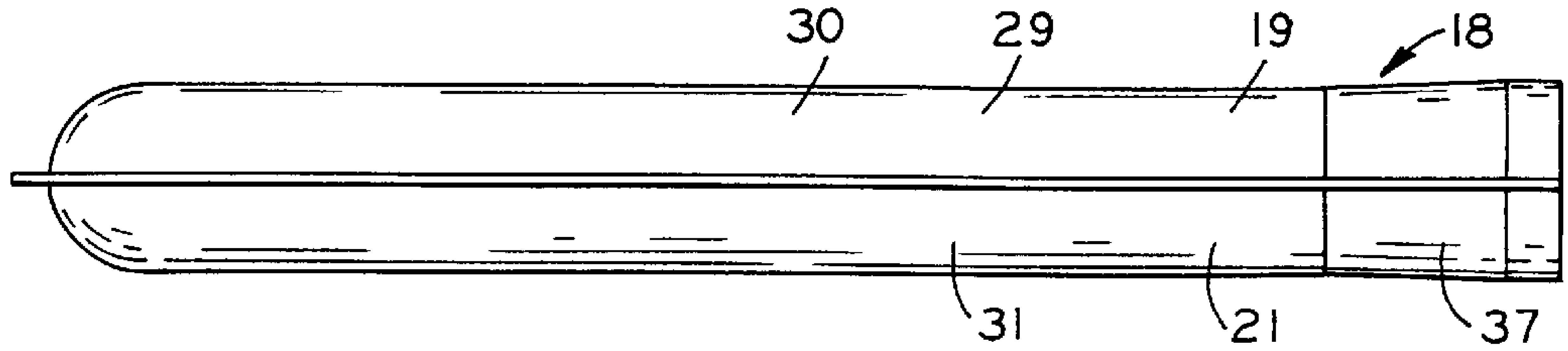

FIG_9

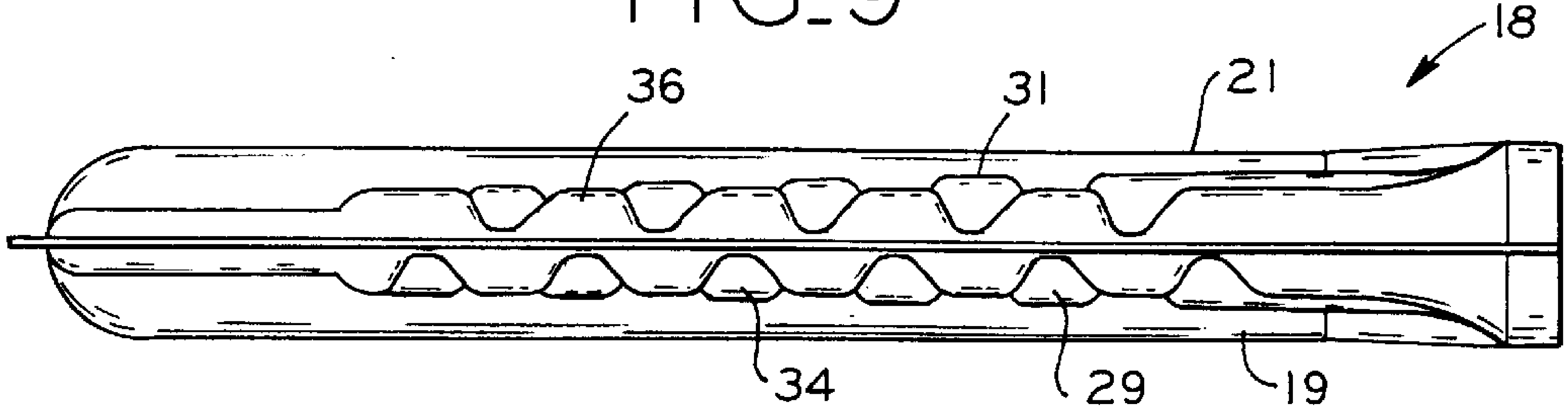

FIG_10

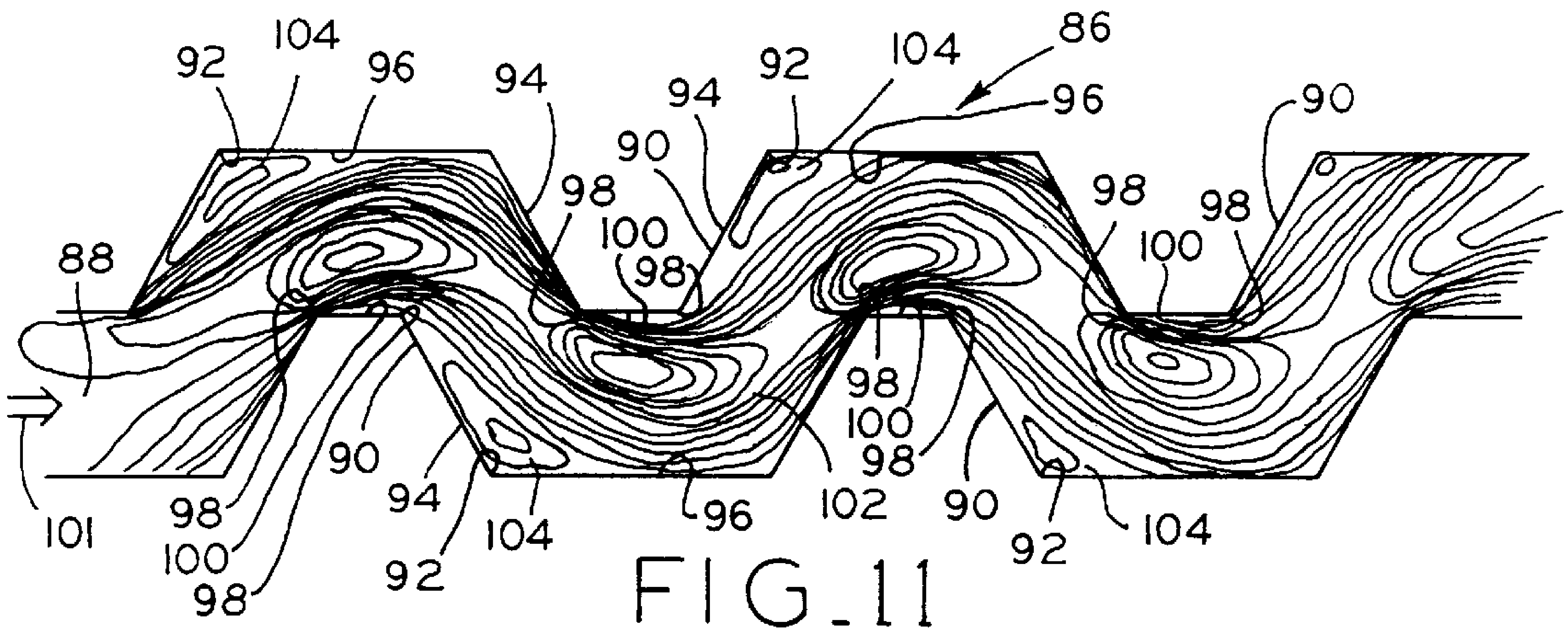

FIG_11

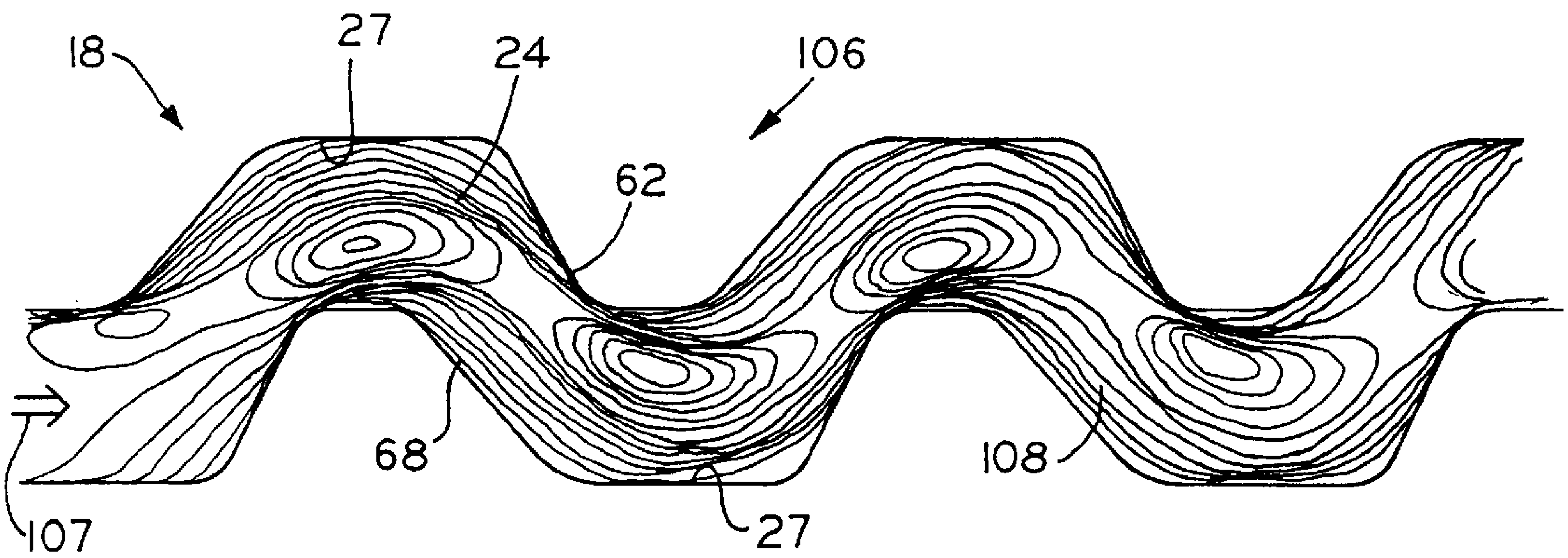

FIG_12

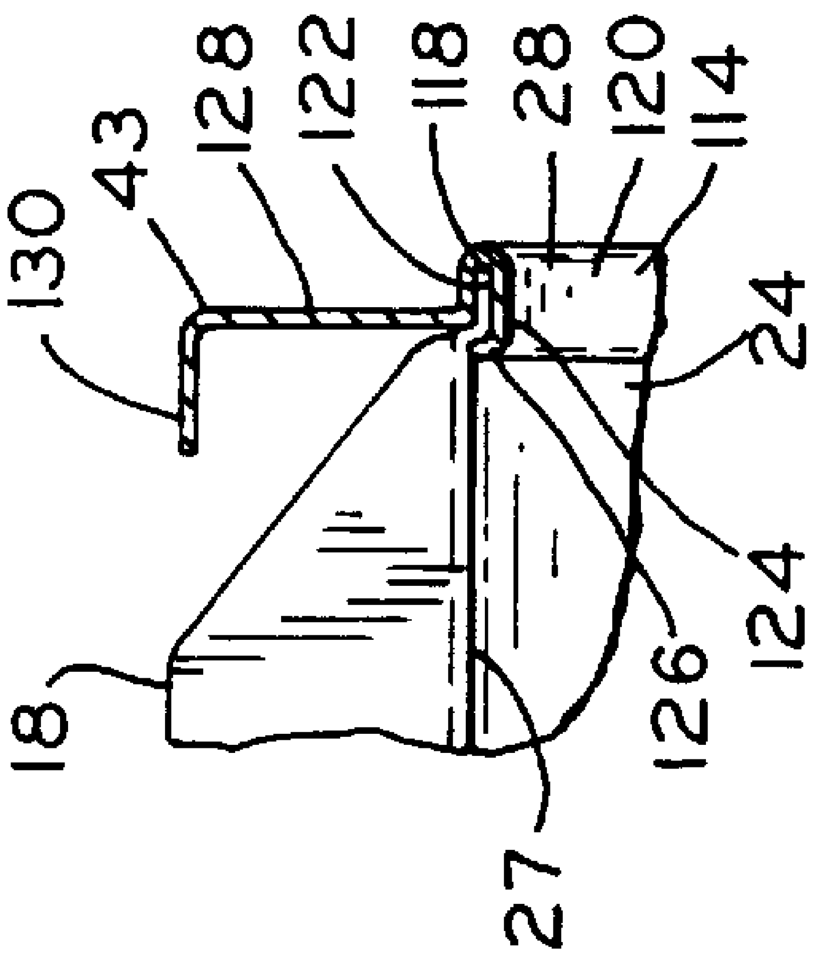
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FIG. 14

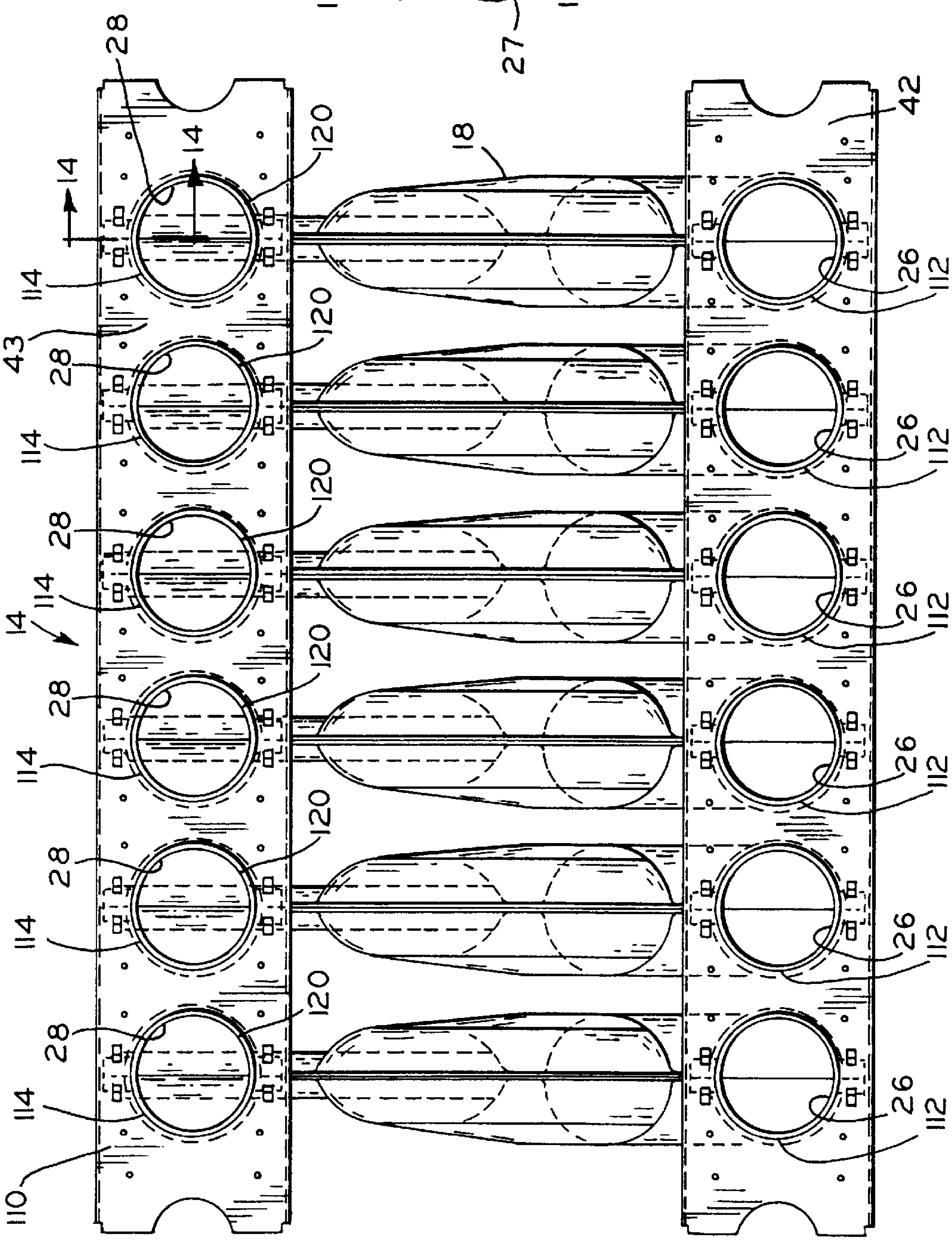
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FIG. 13

HEAT EXCHANGER WITH ENHANCEMENTS

This application claims priority from Provisional application Ser. No. 60/236,969, filed Sep. 29, 2000.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to furnaces and in particular to heat exchangers for use in furnaces.

2. Description of the Related Art

In one form of a conventional domestic furnace, air to be heated is passed in heat transfer association with a plurality of stacked serpentine heat exchanger elements forming a heat exchanger encased in a cabinet. Each heat exchanger element defines a flow path for hot products of combustion produced by combustion of fluid fuel, typically, such fuel may include, for example, oil or natural gas. The hot products of combustion, in passing through the heat exchanger elements, transfer their heat energy to the air to be heated, conventionally referred to as the room air, and are then exhausted through a suitable flue.

Prior art serpentine heat exchangers are typically manufactured from either a continuous tube or in two halves joined together, e.g., "clam-shell", by known bending and/or joining techniques. To increase the heat transfer between the combustion products, contained within the heat exchanger, and the ambient environment residing at the exterior of the same, it is known that forcing the flow to become non-laminar, especially at the latter portion of the exchanger, greatly improves heat transfer.

Flow diverters and separators of many types were added to the interior structure of the exchangers to increase the flow turbulence, however such methods significantly increased manufacturing costs of the heat exchangers. To lessen the expense yet retain acceptable levels of exchanger performance both continuous tube and clamshell type heat exchanger elements included external deformations to create internal flow "turbulators" to increase heat transfer performance at an acceptable additional cost. However, the need has arisen to decrease the size of furnace cabinet and accompanying heat exchanger assembly therein while sustaining equal or increased heat transfer characteristics of the heat exchanger assembly.

U.S. Pat. No. 5,346,001 issued to Rieke et al. discloses a heat exchanger which employs a turbulator region comprised of multiple, interfacing and closely arranged deformations within the clamshells. The deformations are successively and contiguously arranged within each clamshell to promote turbulence, and consequently, enhanced heat transfer within this region. However, the turbulator region causes a significant decrease in flow velocity along portions of the interior walls of the turbulator region which corresponds to a decrease of heat transfer along these wall portions.

A clamshell type heat exchanger assembly which causes turbulent flow, however increases flow velocity at the site of passageway walls to increase heat transfer between the heat exchanger elements and room air would be desirable.

Further, a clamshell type heat exchanger utilizing conventional materials of construction which sealably contains flue gases while using less heat exchanger materials, consequently providing a significant cost decrease, as compared to prior art exchangers, would be desirable.

SUMMARY OF THE INVENTION

The present invention overcomes the disadvantages of prior art furnaces by employing a heat exchanger including a plurality of clamshell elements having trapezoidal enhancements to significantly increase the heat transfer and provide an overall smaller or compact furnace corresponding to a reduction of manufacturing and assembly costs.

The present invention provides a heat exchanger for use with a furnace including a plurality of heat exchanger elements having internal structures which receive hot products of combustion and transfer heat to room air being externally forced over each heat exchanger element. Each heat exchanger element includes a pair of clamshells, having depressions facing one another. The depressions are sealingly clamped to one another and form a passageway wall and a serpentine fluid passageway therebetween. The depressions within the clamshells define an inlet and an outlet in fluid communication through the serpentine flow passageway. A plurality of enhancements are disposed within the depressions defined in the clamshells and extend into the flow passageway. Each enhancement is provided with a corrugation and each corrugation includes a substantially trapezoidal cross-section. Longitudinally positioned passageway wall portions extend between adjacently positioned enhancements within each clamshell. The plurality of enhancements are structured and arranged with the passageway wall portions to direct a flow of products of combustion received in the heat exchanger element along the passageway wall at a non-zero velocity.

The present invention heat exchanger, in one form thereof, includes a heat exchanger element having enhancements in one clamshell coacting with enhancements in the other clamshell to increase the heat transfer between the flow of hot products of combustion through the element with room air flowing externally over the element. Each enhancement defines upstream and downstream ramping portions separated by a plateau and having respective angles of inclination and declination.

The heat exchanger of the present invention further provides at least one heat exchanger element having a pair of clamshells. The clamshells include a serpentine fluid passageway therein which receives hot products of combustion. The fluid passageway includes an inlet channel and at least one enhancement channel positioned downstream relative to the inlet channel. The inlet and enhancement channels are in fluid communication with one another and a plurality of enhancements are disposed within the enhancement channel. The enhancements reduce zones of recirculation formed by the hot products flowed through the passageway and correspondingly increase the heat transfer between the hot products of combustion and room air being urged externally over the heat exchanger element.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and advantages of the present invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a perspective view of a furnace adapted with a plurality of heat exchanger elements according to the present invention showing the heat transfer enhancements thereon;

FIG. **2** is a perspective view of a first embodiment of a right-hand half section of the heat exchanger with enhancements according to the present invention;

FIG. **3** is a plan view of one of the heat exchanger elements of the heat exchanger element of FIG. **1**, showing the right-hand half section;

FIG. **4** is a plan view of the heat exchanger element of FIG. **3**, showing the left-hand half section;

FIG. **5** is a sectional view of the heat exchanger according to the present invention taken along line **5—5** of FIG. **3**, showing a first enhancement channel;

FIG. **6** is a sectional view of the first embodiment heat exchanger according to the present invention taken along line **6—6** of FIG. **3**, showing the enhancements within a second enhancement channel;

FIG. **6**A is an enlarged view of the encircled area of FIG. **6**, illustrating a pair of interfacing enhancements;

FIG. **6**B is an enlarged fragmentary view of a second embodiment heat exchanger according to the present invention, showing a pair of enhancements;

FIG. **6**C is an enlarged fragmentary view of a third embodiment heat exchanger according to the present invention, showing a pair of interfacing enhancements;

FIG. **7** is a sectional view of the heat exchanger element of FIG. **3** taken along line **7—7**;

FIG. **8** is an end view of the heat exchanger element of FIG. **3** viewed along line **8—8**;

FIG. **9** is a top view of the heat exchanger element of FIG. **3** viewed along line **9—9**;

FIG. **10** is a bottom view of the heat exchanger element of FIG. **3** viewed along line **10—10**;

FIG. **11** is a flow model of a heat exchanger having angled symmetrical enhancements, showing the stream-line contours of the hot products of combustion flowing therethrough;

FIG. **12** is a flow model of the first embodiment heat exchanger according to the present invention, showing the stream line contours of the hot products of combustion flowing therethrough;

FIG. **13** is a plan view of the heat exchanger bank according to the present invention, showing the inlet and outlet ports; and

FIG. **14** is an enlarged fragmentary sectional view of the heat exchanger according to the present invention, viewed along line **14—14** of FIG. **13**.

Corresponding reference characters indicate corresponding parts throughout the several views. Although the drawings represent embodiments of the present invention, the drawings are not necessarily to scale and certain features may be exaggerated in order to better illustrate and explain the present invention. The exemplifications set out herein illustrate embodiments of the invention, and such exemplifications are not to be construed as being exhaustive or to limit the scope of the invention in any manner.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. **1**, furnace **10** is shown including outer housing, or cabinet **12**. Mounted within cabinet **12** is heat exchanger bank generally designated **14**. Air to be conditioned, hereinafter referred to as room air, is delivered to heat exchanger bank **14** by blower **16**. Heat exchanger bank **14** is defined by a plurality of side-by-side heat exchanger elements **18** providing therebetween a plurality of air flow passages **20** for passing air delivered from blower **16** in heat transfer association with each heat exchanger element **18**. Hot products of combustion or flue gases are flowed through the interiors of heat exchanger elements **18** from a burner means (not shown) having a plurality of individual burners (not shown) and each burner is associated with a respective heat exchanger element **18**. The products of combustion from the respective heat exchanger elements are forcibly exhausted by an exhaust blower (not shown), for example, from the furnace through a discharge flue (not shown) by known means.

Blower **16** is adjacently disposed relative to horizontal divider wall **17** so as to deliver the air to be conditioned upwardly through an inlet opening (not shown) in divider wall **17** which thereafter communicates with heat exchanger flow passages **20**. After passing in external heat exchange relationship with the heat exchanger elements **18**, the heated air is conducted to the space to be heated by suitable duct means (not shown). Subsequently, the room air may be recirculated through the furnace by suitable return ducts (not shown) to blower **16**.

Referring to FIGS. **2–4**, each heat exchanger element **18** is formed by preforming a pair of individual plates or "clamshells." Each element includes right-hand clamshell **19** (FIGS. **1–3**) and left-hand clamshell **21** (FIG. **4**). Clamshells **19** and **21** include depressions **29**, **31** forming the serpentine configuration illustrated in FIGS. **2–4**, having peripheral edge **23** of heat exchanger element **18** secured together in sealed relationship by a turned end portion or crimp **25** (FIG. **5**). The crimped engagement of clamshells **19** and **21** is the subject of U.S. Pat. Nos. 4,298,061; 4,441,241; 4,510,660; 4,538,338; 4,547,943; 4,649,894; 4,663,837; 4,718,484; and 4,893,390 and are hereby incorporated herein by reference. Referring to FIGS. **3–4**, it may be seen that eyelets **39** are arranged about inner portions of clamshells **19**, **21** specifically along passageway **24**, to prevent combustion products from escaping through the interior of clamshells **19**, **21**. Each eyelet **39** is comprised of material from one clamshell protruding through a hole extended through the other clamshell (FIG. **7**). The material protruding through is then "rolled over" to produce a secure engagement between clamshells. Clamshells **19** and **21** of heat exchanger element **18** may be comprised of corrosion resistant metallic materials, such as aluminized steel, stainless steel, or a coated metal material, for example.

Referring to FIGS. **1–4**, each pair of depressions **29**, **31** of heat exchanger element **18** defines a serpentine products of combustion passageway **24**, formed by passageway walls **27** (FIG. **6**A), having an inlet **26** and an outlet **28**. Referring to FIG. **3**, the hot products of combustion received from the respective burners enter passageway **24** through inlet **26**. Serpentine fluid passageway **24** includes an inlet channel **30** which is U-shaped and extends in a direction coincident with longitudinal reference axis **33**. Inlet channel **30** is transversely arranged relative to air flow passages **20** defined between the respective heat exchanger elements **18** and walls **32** comprising cabinet **12** (FIGS. **1** and **2**). As best seen in FIG. **3**, each heat exchanger element **18** includes two enhanced heat transfer channels, namely, first enhancement channel **34** and second enhancement channel **36**. Channels **30**, **34**, and **36** longitudinally extend along longitudinal axis **33** and are generally parallel to each other. Further, it may be seen that enhancement channels **34** and **36** are perpendicularly arranged relative to the direction of air flow from blower **16** (FIG. **1**).

Referring to FIG. **3**, serpentine fluid passageway **24** is formed from an interfaced relation between depression **29** of clamshell **19** and depression **31** of matching clamshell **21**. Depressions **29**, **31** define inlet **26**, outlet **28**, and passageway **24** extended therebetween. Passageway **24** fluidly connects inlet and outlet **26** and **28**. Inlet and outlet manifolds **42**, **43** (FIG. **1**) are attached to respective inlets and outlets **26**, **28** of heat exchanger elements **18** to accommodate connection to a burner assembly (not shown) and an exhaust blower assembly (not shown).

Attached to inlet manifold **42** (FIG. **1**) is inlet channel **30** provided with U-shaped bend **44** at peripheral edge **23** of heat exchanger element **18**. Inlet channel **30**, generally circular in cross-section (FIG. **7**), is provided with a converging nozzle portion **37** (FIG. **2**) and is connected to first enhancement channel **34** through U-shaped bend **46** (FIG. **5**). Bend **46**, transitions from a generally circular cross-section at its connection with inlet channel **30**, to a non-circular cross-section **35** (FIGS. **7–8**) as it merges into first enhancement channel **34**. Referring to FIG. **2**, first enhancement channel **34** becomes increasingly flat and connects with flat U-shaped bend **48** through reduction connector **49** (FIG. **2**). Bend **48** is substantially uniformly flat and connects first and second enhancement channels **34, 36** (FIGS. **5–6**). Flat bend **48** provides a decreased flow area corresponding to an increase in velocity of flow of hot products of combustion in preparation for urging the flow through second enhancement channel **36**. In the exemplary embodiment, the "flatness" or reduction in height of first enhancement channel **34** may be 5.9 mm over a 275.4 mm length, for example.

Referring to FIGS. **1–4**, serpentine fluid passageway **24** includes trapezoidally shaped, spaced corrugations or enhancements transversely arranged relative to longitudinal reference axis **33**, provided on first and second enhancement channel portions **34, 36**, respectively. First enhancement channel portion **34** includes enhancements **50–54** (FIG. **3**) formed on clamshell **19** internested or staggered with enhancements **55–59** (FIG. **4**) formed on clamshell **21**. The staggered relationship is best seen in FIG. **5** as the alternating enhancements form a generally saw-toothed passageway for hot products of combustion to turbulently flow therethrough. Similarly, second enhancement channel **36** includes enhancements **60–64** (FIG. **3**), formed in clamshell **19**, in an internested relationship with enhancements **65–69** (FIG. **4**) formed in clamshell **21**, to provoke flow turbulence and increased heat transfer. In contrast to first enhancement channel **34** illustrated in FIG. **5**, passageway walls **27** (FIG. **6**) of second enhancement channel **36** do not taper and are generally uniformly spaced relative to the space formed between clamshells **19, 21**.

Referring to FIG. **6A**, second enhancement channel **36** of the first embodiment heat exchanger **18** is shown, illustrating asymmetrically arranged enhancements **62** and **68**. Specifically, second enhancement channel **36** includes enhancement **68** having upstream ramp **71** and downstream ramp **72** respectively positioned at angles of inclination and declination α and θ measured relative to longitudinal reference line **74**. Arrow **75** illustrates the direction of flow for the hot products of combustion flowing therethrough (FIGS. **5** and **6**). Further, it may be seen that located between wall **27** of passageway **24** and ramp **71** is arced intersection **76**. Plateau **78** is provided between ramps **71** and **72** and a pair of rounded edges **80, 82** are provided at the intersection of plateau **78** and respective ramps **71, 72**. Additionally, arced intersection **84**, positioned downstream relative to engagement portion **68**, is provided between the intersection of ramp **72** and passageway wall **27**.

In the exemplary embodiment, upstream and downstream ramps **71** and **72** may have angles of inclination and declination of α and θ of 63° and 47°, respectively. Further, rounded edges **80, 82** may each include an inside radius of 6.9 mm and arced intersections **76** and **84** may have respective inside radii of 7.6 mm and 15.2 mm. Accordingly, each raised enhancement may extend into passageway **24** depth "D" of 14 mm, for example.

Referring to FIGS. **6** and **6A**, enhancement **62** is generally a mirror image of enhancement **68**, however enhancement **62** is arranged offset, relative to enhancement **68**. In the exemplary embodiment substantially all of the enhancements are of similar construction and include each upstream ramp **71** positioned upstream of each counterpart downstream ramp **72** (FIG. **6A**). However, an infinite selection of ramp angles and enhancement contours are possible which may be common or differ between individual enhancements to provide enhanced heat transfer characteristics.

Referring to FIGS. **6B** and **6C**, shown are additional exemplary embodiments of the present invention which also provide enhanced heat transfer characteristics between hot products of combustion and room air. Specifically, and with reference to FIG. **6B**, shown is a second embodiment heat exchanger including second enhancement channel **36*b*** of heat exchanger element **18*b***. Heat exchanger element **18*b*** includes a similar number and spacing of enhancements as compared to heat exchanger **18**, however differs therefrom in several aspects. One such difference corresponds to enhancement **68*b*** which includes upstream and downstream ramps **71*b*, 72*b***, provided with respective angles α_b and θ_b, measured from longitudinal reference line **74*b***. Angles α_b and θ_b are substantially similar. Yet, it may be seen that enhancement **68*b*** is asymmetrical due to arced intersection **84*b*** having a significantly larger radius relative to arced intersection **76*b***. For example, angles α_b and θ_b, may each be 63° and arced intersections **76*b*** and **84*b*** may have 4.6 mm and 15.2 mm inside radii, respectively. Rounded edges **80*b*, 82*b*** may each be provided with a 4.6 mm inside radius and depth D_b of enhancements **62*b*, 68*b*** may be 16.3 mm, for example.

Referring to FIG. **6C**, shown is a third embodiment heat exchanger provided with enhancements **62*c*, 68*c*** within second enhancement channel **36*c*** of heat exchanger element **18*c***. Enhancement **68*c*** differs from enhancement **68** in that it is symmetrically arranged and angles α_c and θ_c of ramps **71*c*, 72*c*** are substantially identical. Also, it may be seen that arced intersection **76*c*** is substantially similar to that of arced intersection **84*c***. For example, angles α_c and θ_c may each be 63°, arced intersections **76*c*** and **84*c*** each may include an inside radius of 3.8 mm and rounded edges **80*c*, 82*c*** may be 4.6 mm measured at their respective inside radii. Further, enhancements **62*c*, 68*c*** may include depth D_c of 16.3 mm, for example.

Referring to FIG. **11**, shown is a first flow model with uniform and sharply formed enhancements **90**. Passageway **88** accommodates the flow of hot products of combustion which are illustrated by flow arrow **101** and flow streamline contour **102**. First flow model **86** does not directly correspond to any of the described embodiments of heat exchangers of the present invention, however the disclosure of its structure and function is fundamental to understanding the operation of the exemplary embodiments of the inventive heat exchangers according to the present invention. Flow model **86** includes uniform enhancements **90** which are intersected to form generally saw-toothed shaped passageway **88** therebetween. First flow model **86** includes intersections **92** formed between each ramp **94** and adjacently positioned wall portion **96**. Each enhancement **90** includes a pair of edge portions **98** separated by a generally planar plateau portion **100**. It may be seen that the hot products of combustion flowing through passageway **88**, indicated by arrow **101**, form flow streamline contour **102**. Streamline contour **102** represents a velocity gradient of flow through passageway **88** wherein an increased number of lines represents an increased flow velocity. Those having ordinary skill in the art will appreciate that increased velocity of the combustion products is directly related to increased heat transfer. Proximate to edge portions **98**, contour **102** illustrates an increased velocity region. In contrast, proximate to the intersections **92** the velocity is generally insignificant shown by a lack of streamlines, and moreover this deficiency of streamlines corresponds to "recirculation zones" **104**. Recirculation zones **104** represent flow stagnation corresponding to low flow velocity and insignificant heat transfer.

Referring to FIG. **12**, shown is second flow model **106** which corresponds to the first embodiment heat exchanger **18** according to the present invention. In contrast to flow model **86** shown in FIG. **11**, second flow model **106** illustrates a flow of hot products of combustion indicated by flow by arrow **107**, forming streamline curve **108** having little or no recirculation zones. Flow streamline curve **108** in FIG. **12** discloses a generous number of streamlines in close proximity to passageway walls **27** corresponding to increased flow velocity and enhanced heat transfer between the hot products of combustion flowing through passageway **24** and room air circulating over external surfaces of passageway walls **27**. Similarly, the second and third embodiment heat exchangers include respective heat exchanger elements **18***b*, **18***c* exhibiting substantially similar flow performance and heat transfer characteristics to that of flow contour **108** of FIG. **12**.

Referring to FIGS. **1** and **13**, arrangement of the heat exchanger elements to form a heat exchanger or bank **14** will now be described. As best seen in FIG. **13**, each heat exchanger element **18** is supported by being attached to inlet manifold **42**, outlet manifold **43** and L-shaped support member **110** (FIG. **1**). The distance between any two adjacent each heat exchanger elements is predetermined by the spacing of inlet holes **112**, in inlet manifold **42**, and outlet holes **114**, in outlet manifold **43** (FIG. **13**). Each heat exchanger element **18** includes an annular inlet rim **116** (FIG. **2**) and outlet rim **118** (FIG. **2**), which respectively attach to inlet and outlet manifolds **42**, **43**. Each outlet rim **118**, as best illustrated in FIG. **14**, is sealingly attached to outlet manifold **43** utilizing a crimping relationship to form a gas-tight seal therebetween. U-shaped sleeve **120**, which includes slot **122**, is engaged by annular protrusion **124** provided by heat exchanger element **18**. Sleeve **120** extends into passageway **24** of heat exchanger element **18** and is bent over at bend **126** to sealably join outlet manifold **43** with heat exchanger element **18**. Outlet manifold **43** includes flange portion **128** extended radially, outwardly from each outlet hole **114** and includes a perpendicular bend **130**, to provide access for the exhaust fan assembly (not shown). It will be understood that the sealed engagement of inlet manifold **42** with each heat exchanger **18** is similar to the sealed engagement of outlet manifold **43** with each heat exchanger **18** previously described.

While this invention has been described as having exemplary designs, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

What is claimed is:

1. A heat exchanger for use with a furnace, said heat exchanger comprising:

a plurality of heat exchanger elements, each said heat exchanger element including a pair of clamshells sealingly attached to one another, each said heat exchanger element having a longitudinal axis, a pair of depressions disposed in each respective said pair of clamshells, said depressions facing one another to form a passageway wall and a serpentine fluid passageway therebetween, at least a portion of said serpentine fluid passageway extending along said longitudinal axis, a plurality of enhancements in said depressions and disposed within said portion of said serpentine fluid passageway, said plurality of enhancements projecting into said serpentine fluid passageway, each said enhancement comprising a transversely extending corrugation having a substantially trapezoidal longitudinal cross-section, a longitudinally positioned passageway wall portion extending between adjacently positioned enhancements within each clamshell, at least one enhancement channel defined by a portion of said serpentine passageway, said enhancement channel including said corrugations, said corrugations disposed one of said pair of depressions including ramping surfaces in fluid communication with ramping surfaces defined by the corrugations disposed on the other depression, each of said ramping surfaces including an angle of inclination followed by an angle of declination, said angle of inclination greater than said angle of declination, said plurality of enhancements structured and arranged with said passageway wall portions to direct a flow of products of combustion received in said heat exchanger element along said serpentine fluid passageway wall at a non-zero velocity, whereby a flow velocity of hot products of combustion is registerable through substantially said entire enhancement channel at positions proximate to said ramping surfaces.

2. The heat exchanger of claim **1**, wherein said serpentine fluid passageway includes an inlet and an outlet and a plurality of longitudinally arranged channels fluidly connecting said inlet and said outlet, said channels fluidly connected by bend portions.

3. The heat exchanger of claim **1**, further comprising a first manifold wherein said each heat exchanger element is fixed relative to an adjoining said heat exchanger element through said first manifold.

4. The heat exchanger of claim **3**, further comprising a second manifold, said first manifold is attached to either said inlets or outlets of said serpentine passageway and said second manifold is attached to the remaining of said inlets or outlets.

5. The heat exchanger of claim **3**, further comprising a support member attached to a periphery portion of each said heat exchanger element.

6. The heat exchanger of claim **1**, wherein said corrugations on one of said pair of clamshells are offset and interested relative to the other corrugations of the other said clamshell to form a continuous saw-toothed passageway disposed in said portion of said longitudinally arranged serpentine fluid passageway.

7. The heat exchanger of claim **6** wherein said saw-toothed passageway includes a substantially uniform longitudinal cross-section.

8. The heat exchanger of claim **6**, wherein said saw-toothed passageway tapers longitudinally in the direction of the flow through said serpentine fluid passageway.

9. A heat exchanger element for use with a furnace, said heat exchanger element comprising:

a pair of clamshells sealingly attached to one another, said heat exchanger element having a longitudinal axis, a pair of depressions disposed in said pair of clamshells, said depressions facing one another to form a passageway wall and a serpentine fluid passageway therebetween, at least a portion of said serpentine fluid passageway extending along said longitudinal axis, a plurality of enhancements in said depressions and disposed within said portion of said serpentine fluid passageway, said plurality of enhancements projecting into said serpentine fluid passageway, each said enhancement comprising a corrugation having a substantially trapezoidal longitudinal cross-section, a longitudinally positioned passageway wall portion extending between each adjacently positioned enhancements within each clamshell, at least one enhancement channel defined by a portion if said serpentine passageway, said enhancement channel including said corrugations, said corrugations disposed on one of said pair of depressions including ramping surfaces in fluid communication with ramping surfaces defined by the corrugations disposed on the other depression, each of said ramping surfaces including an angle of inclination followed by an angle of declination, said angle of inclination greater than said angle of declination, said plurality of enhancements structured and arranged with said passageway wall portions to direct a flow of products of combustion received in said heat exchanger element along said serpentine fluid passageway wall at a non-zero velocity, whereby a flow velocity of hot products of combustion is registerable through substantially said entire enhancement channel at positions proximate to said ramping surfaces.

10. The heat exchanger element of claim **9**, wherein one of said pair of depressions includes said corrugations being internested with the other said corrugations on the other said depression.

11. A heat exchanger for use with a furnace, said heat exchanger including at least one heat exchanger element which receives hot products of combustion therein and having room air being forced externally thereover, the heat exchanger element comprising:

a pair of clamshells each having a depression disposed therein and sealingly attached to one another, said depressions defining an inlet and an outlet in fluid communication through a serpentine flow passageway, a portion of said flow passageway defining an inlet channel, at least one enhancement channel disposed in said flow passageway and positioned downstream relative to said inlet channel, a plurality of enhancements provided on said depressions and extended inwardly into said enhancement channel, each said enhancement comprising a transversely extending corrugation having a substantially trapezoidal longitudinal cross-section, a longitudinally positioned passageway wall portion extending between adjacently position enhancement within each clamshell, said enhancements reducing zones of recirculation of the hot products of combustion flowed internally through said flow passageway, said flow passageway including an inlet channel, a first enhancement channel and a second enhancement channel, said first and second enhancement channels defined by a portion of said serpentine passageway, said enhancements confined to said first and second enhancement channels, said first and second enhancement channels including said corrugations, said corrugations disposed on one of said pair of depressions including ramping surfaces in fluid communication with ramping surfaces defined by the corrugations disposed on the other depression, each of said ramping surfaces including an angle of inclination followed by an angle of declination, said angle of inclination greater than said angle of declination, said first and second enhancement channels extending longitudinally, said enhancements transversely disposed within said first and second enhancement channels, said first enhancement channel tapering longitudinally in the direction of internal flow, said second enhancement channel substantially longitudinally uniform, whereby heat transfer is increased between the hot products of combustion and room air urged externally over said at least one heat exchanger element.

12. A heat exchanger element for use with a furnace, each heat exchanger element comprising:

a pair of clamshells sealingly attached to one another, said heat exchanger element having a longitudinal axis, a pair of depressions disposed in said pair of clamshells, said depressions facing one another to form a passageway wall and a serpentine fluid passageway therebetween, at least a portion of said serpentine fluid passageway extending along said longitudinal axis, a plurality of enhancements in said depressions and disposed within said portion of said serpentine fluid passageway, said plurality of enhancements projecting into said serpentine fluid passageway, each said enhancement comprising a corrugation having a substantially trapezoidal longitudinal cross-section, a longitudinally positioned passageway wall portion extending between each adjacently positioned enhancements within each clamshell, said serpentine fluid passageway including an inlet channel, a first enhancement channel and a second enhancement channel, said corrugations confined to said first and second enhancement channels, said first and second enhancement channels extending longitudinally, said corrugations transversely disposed within said first and second enhancement channels, said first enhancement channel tapering longitudinally in the direction of internal flow, said second enhancement channel substantially longitudinally uniform, said plurality of enhancements structured and arranged with said passageway wall portions to direct a flow of products of combustion received in said heat exchanger element along said serpentine fluid passageway wall at a non-zero velocity.

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